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# TWO NEW GENERA OF DINOFLAGELLATES FROM CALIFORNIA[1]

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The coastal waters in the San Diego region support fairly abundant populations of phytoplankton. Armored dinoflagellates of this region were studied extensively by Kofoid and his associates (1907–1933), but there are still numerous undescribed or little known representatives especially among the smaller species. In the present paper, two new genera and species are described. These were originally isolated by Dr. Beatrice M. Sweeney in 1956–57 from coastal water at La Jolla, Calif., and have since been maintained as laboratory cultures.

Acknowledgment is here made to Prof. Francis T. Haxo and Prof. Martin W. Johnson for their interest and for providing research facilities. The author is indebted to Dr. Beatrice M. Sweeney whose cultures made this study possible, to Mrs. Anne Dodson for valued technical aid and to Dr. K. A. Clendenning for assistance in the preparation of the manuscript.

## Methods

The dinoflagellates were first examined alive. Fixed material was then studied under an oil immersion objective and by phase contrast. To derive the general plate formulae of the thecae, an individual cell was isolated under a cover-glass. A drop of concentrated sodium hypochlorite solution was then passed slowly under the cover-glass to destroy the protoplasm and to remove the cement which unites the plates. This process was assisted by applying very gentle pressure to the cover-glass, but great caution was necessary because of the fragility of the specimens. With *Scrippsiella*, it proved helpful to store droplets of the cultures in a wet chamber for a few hours. Under these conditions many of the cells shed their thecae, to which the hypochlorite treatment was then applied. After testing other methods, the following technique was adopted for the examination of *Fragilidium*. Actively swimming individuals were killed by transferring them into 5% formaldehyde with a micropipette. Individual specimens were next isolated, and by applying gentle pressure to the cover-slip, the protoplasm was

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*Scrippsiella sweeneyi* n. gen., n. sp.

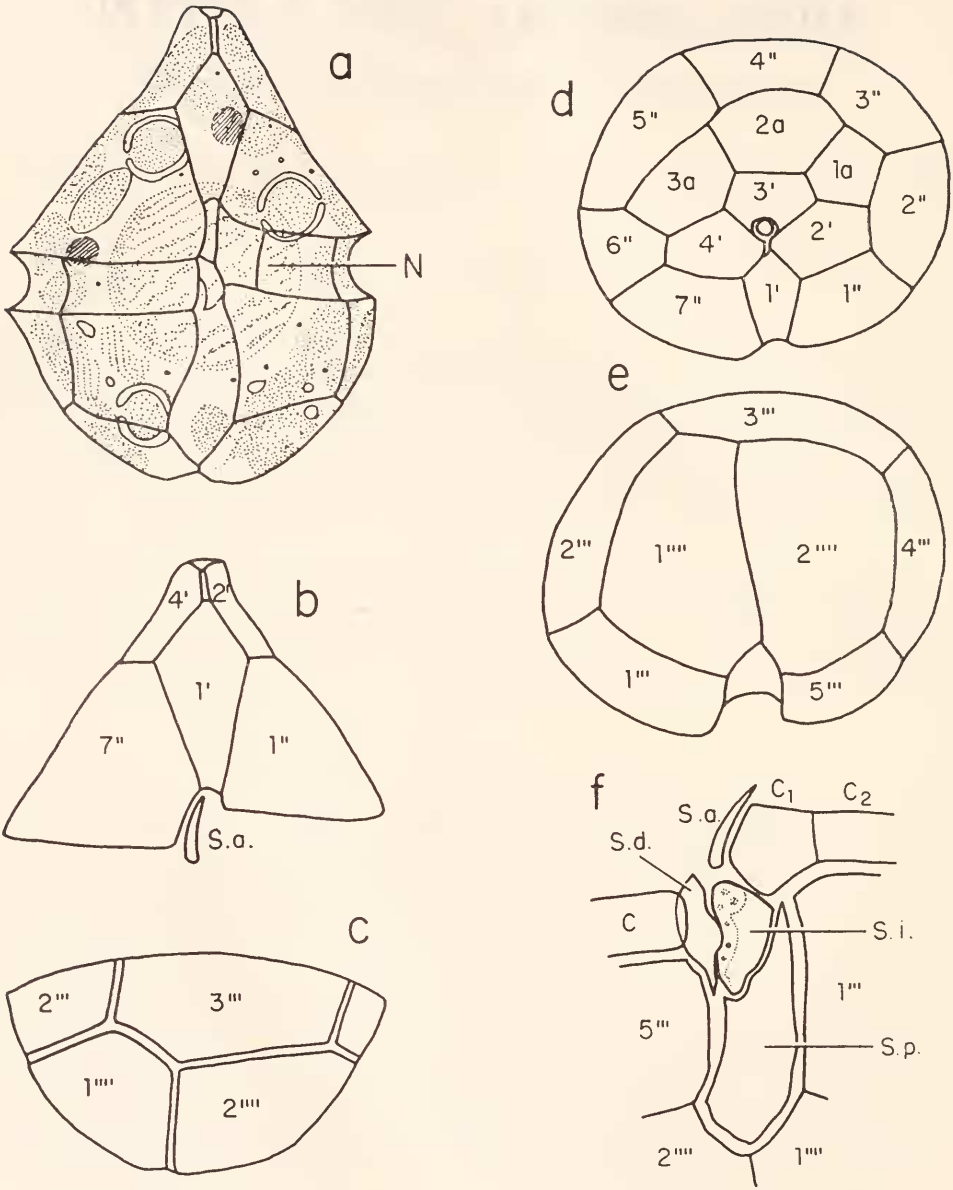


FIGURE 1. *Scrippsiella sweeneyi.* a) A typical individual, ventral view. b) Ventral view of the epitheca. c) Dorsal view of the hypotheca. d) Apical view of the epitheca. e) Antapical view of the hypotheca. f) Sulcal region (S.a.: Anterior sulcal.—S.i.: left sulcal.—S.d.: right sulcal.—S.p.: posterior sulcal). All figures about × 1500.

forced out of the theca through the cingular region. The hypochlorite treatment was then applied to the empty *Fragilidium* theca, especially in studies of the sulcus and cingulum.

*Diagnosis.* Small-sized, conical epitheca, rounded hypotheca, without horns. Cingulum wide, cavazone, descendent, with displacement equal to two-thirds of its width, without lists. The cingulum has six plates, five equal, preceded at the left by a transitional one. Sulcus deep, of medium width, slightly curved to the right.

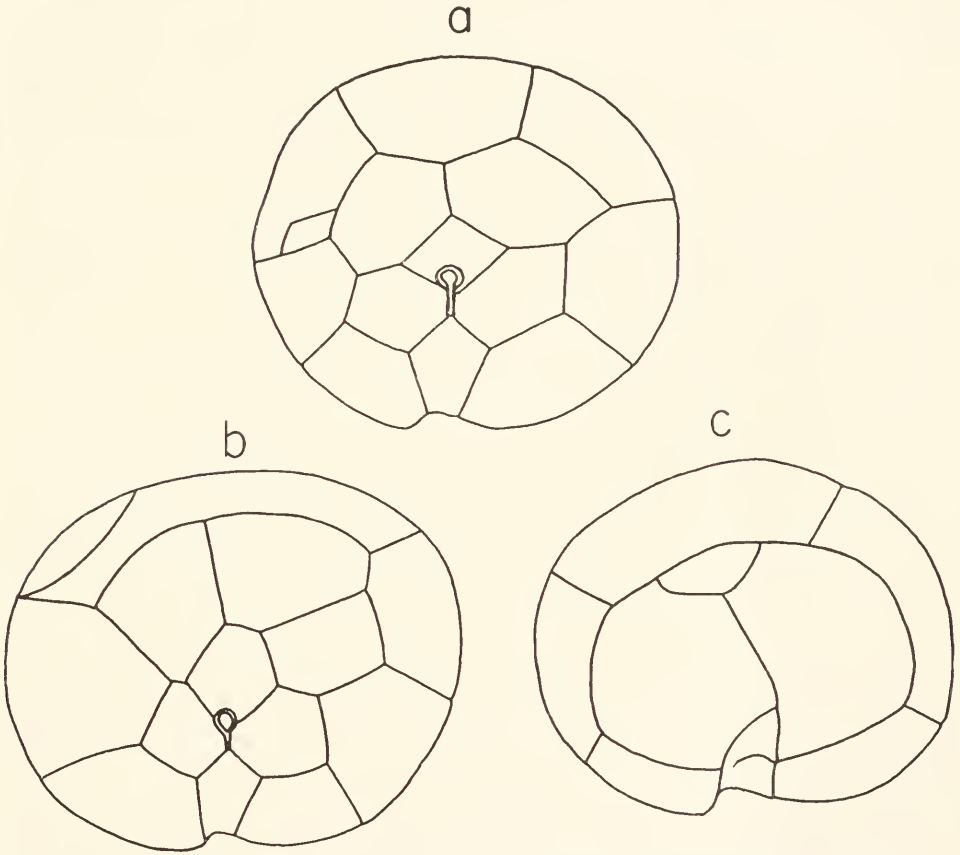


FIGURE 2. *Scrippsiella sweeneyi,* atypical plate patterns. a and b) Two epithecae, apical view. c) Antapical view of a hypotheca. All figures about × 1500.

The sulcus has four plates, with the posterior plate largest. The pattern of the major body plates is the same as that of an *Orthoperidinium* with three intercalaries. Cell length, 24–32.5 μ; transdiameter, 19–24 μ, chromoplasts numerous, elliptical, generally brown-yellow. La Jolla, California.

*Description.* This organism resembles *Peridinium trochoideum* in its general shape and size, and to some degree in its plate formula: 4′, 3a, 7″, 6c, 5‴, 2‴ ″, and 4s. Its epitheca is high and conical, most individuals deviating from a

rectilinear outline by a concavity near the apex, as shown in Figure 1a. The hypotheca is almost hemispherical, and slightly shorter in length than the epitheca. In the region of the girdle, there is a slight dorsiventral compression. In apical view, the cells normally appear almost circular. The sulcus indents slightly into the epitheca, is very deep, and of medium width. It does not reach the antapex when in true frontal view.

The plate pattern of the major body plates is the same as that of an *Orthoperidinium* with three intercalaries. In the epitheca, the first apical plate (1′) is very narrow, with an asymmetrical rhombic shape and upwardly curved base. Attached to its anterior end, there is an extremely narrow ventral apical plate. The apex of the theca is horizontal, and is closed by a circular plate (apical pore platelet) which indents the pentagonally shaped third apical plate (3′). Plates 2′ and 4′ are comparatively large, and generally 2′ is a little wider than 4′. There are three dorsal intercalaries. Plate 2a is usually pentagonal but is sometimes hexagonal.

In the hypotheca, there are five post-cingulars and two antapicals. Plates 1″ ′ and 5″ ′ are wide, and 3″ ′ is very asymmetrical; its border with 2″ ″ is very long in comparison with its border with 1″ ″. The two antapicals have a very restricted connection with the end of the sulcus.

The cingulum has five plates of similar size, plus a transitional plate at the left end which is somewhat different in shape and also a little higher than the other cingular plates.

The sulcus of dinoflagellates is not easily examined, and has been neglected by most protistologists for that reason. The sulcus of *Scrippsiella sweeneyi* is exceptionally difficult to analyze, being about as difficult to study as that of *Heterocapsa triquetra*. The anterior sulcal plate (S.a.) is narrow and a little curved. It borders 7″. Posterior to this plate are two smaller plates (S.i. and S.d.). The shorter and broader of these two is the left plate (S.i.), which extends very slightly beyond the distal end of the girdle. The right border of this plate (S.i.) is thickened and refringent; it is provided with poroids and at the extreme anterior end there are two closely spaced pores. The right sulcal plate (S.d.) narrows toward the posterior. The posterior plate (S.p.) is the largest, forming the greatest part of the sulcus. Its right anterior border is strongly oblique to the axis of the plate and articulates with S.i. The posterior right border of S.p. is thickened.

The nucleus is round and located at the girdle level. Its diameter is about one-third of the total cell length. The chromatin strands are less evident than in most dinoflagellates. The chromoplasts are elliptical and numerous, sometimes yellow-green but normally brown-yellow. Food is apparently stored as small granules and also around the chromoplasts in bodies that resemble pyrenoids. There is no pusule nor stigma.

The first external evidence of cell division is the formation of two discrete longitudinal flagella with separate points of attachment. During division, the cell escapes from the theca but retains a tough cellular membrane. The two daughter cells remain attached to each other in an oblique plane. The posterior cell is usually the smallest.

Locomotion is normally rapid, with a strongly rotatory motion. There is usually

one complete rotation of the organism during an advancement of one or two cell lengths. Sometimes, when *S. sweeneyi* cells reach the border of a drop, they suddenly cast off their flagella. Generally they lose the transverse ribbon-like flagellum first, which continues to beat in the detached state for a few seconds and then vacuolizes. The longitudinal flagellum is about three times as long as the cell; it does not beat or vacuolize after detachment.

*Occurrence.* This organism was originally isolated on March 15, 1956, from water collected off the S.I.O. pier at La Jolla, California, and has since been observed frequently in locally collected water samples. It seems to be a year-round inhabitant of the San Diego region, thriving especially in the summer months. This species has also been observed in plankton net samples, its relative scarcity in these being caused by its small size and poor retention on plankton silk.

*Variations.* The cingular and sulcal formula has been constant in laboratory and field specimens: 6C and 4S. The cells varied in size, and in the laboratory clonal culture used in the description, the cells also varied in shape and in plate pattern. Deformed or aberrant forms of *S. sweeneyi* were numerous in old laboratory cultures, but these were not observed in plankton samples. The plate formulae of the thecae from plankton samples were established in only a few cases, so we do not yet know how much the plate formula of this organism varies in nature. On the whole, the plate pattern has shown an amazing range of variation.

The normal plate formula is as stated above: 4′, 3a, 7″, 6c, 5‴, 2⁗, and 4s. It is generally assumed that the hypotheca is more conservative than the epitheca, and this is true of the present organism. Deviations from the normal epithecal plate configuration were observed in about 10 per cent of the specimens examined. The range of variation encountered in the atypical specimens of *S. sweeneyi* was rather exceptional for dinoflagellates, although similar variations occur in *Pyrophacus horologicum*. Plate formulae in these atypical specimens were:

(1) 4′, 2a, 6″;
(2) 4′, 3a, 5″;
(3) 4′, 3a, 4″;

A single specimen with 3′, 3a and 5″ showed an exceptional overgrowth of 1″, which reached the apical pore thus transforming 2′ into 1*a*.

No alteration of hypothecal formula has been noticed in actively growing cultures. In old cultures, I have observed hypothecal formulae of: 5‴, 2⁗ and one intercalary; 4‴, 2⁗; and 3‴, 2⁗ and one intercalary. However, the plate variation of the hypotheca has not exceeded two per cent in all examined specimens.

*Discussion.* The general characteristics of this organism place it in the *Peridiniaceae*. If it were classified solely on the basis of its major body plates, it would be included in the genus *Peridinium*. The cingular formula and sulcus plates are characteristically different, however, from those of *Peridinium*. The cingular and sulcal plates are conservative and important structural features connected with the most dynamic parts of the cell. Undoubtedly this organism belongs to a new genus. The species is also new. The only other known species which bear general resemblances to the present organism are *Peridinium subsalsum* Ost., and especially *P. trochoideum* (Stein) Lemm. Laboratory cultures of these species were provided by Dr. Sweeney for comparative studies. Their assignment

to the genus *Peridinium* was clearly correct, but they bore only superficial resemblances to *Scrippsiella sweeneyi*. The genus is named after the institution at which it was discovered, and the species is dedicated to Dr. Beatrice M. Sweeney who made the original isolation and whose cultures made this study possible.

*Fragilidium heterolobum* n. gen. n. sp.

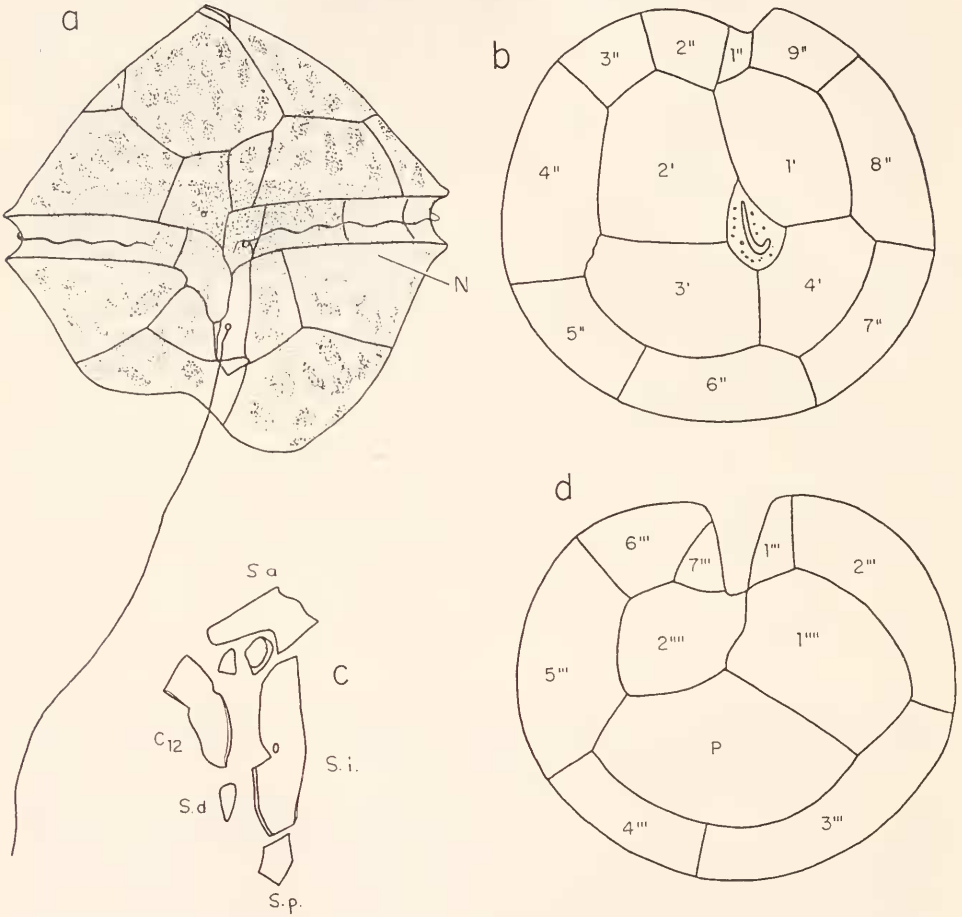


FIGURE 3. *Fragilidium heterolobum*. a) A typical individual, ventral view. b) Apical view of the epitheca. c) Sulcal plates. d) Antapical view of the hypotheca. All figures about × 1000.

*Diagnosis*. Medium-sized, roughly roundish pentagonal in ventral view. Epitheca dome-shaped; hypotheca asymmetrically bipedal, the left lobe being the largest. Cingulum deeply impressed, subcentral, descending, displaced distally about one girdle width, without lists. The cingulum has eleven sub-equal rectangular plates plus a transitional plate at the right end. Sulcus narrow, only slightly excavated, with six plates. Theca easily exuviated. Cell length 53–56 $\mu$,

transdiameter 48–54 $\mu$. Chromoplasts numerous, elliptical, brown. Genus characterized by the high number of precingular, postcingular and cingular plates. La Jolla, California.

*Description*

*Plate pattern.* The epithecal formula is 4′, 9″ and a "pore platelet." The plate 1′ is in general large and it has the most irregular form. It has connections with seven plates: 1″, 2″, the pore platelet, 4′, 8″ and 9″; its border for 2″ is the smallest. Plate 1′ is asymmetrically located, most of it being on the right side of the epitheca; its width decreases gradually to the left. The other three apicals are more regular. Apical 2′ has six edges (for 1′, 3′, the pore platelet, 2″, 3″, 4″). The plate 3′ touches 2′, 4′, 4″, 5″, 6″ and the pore platelet. The apical 4′ touches 3′, 1′, 6″, 7″, 8″ and the pore platelet.

The so-called pore platelet is relatively large, oval sigmoid, and placed obliquely, to the median plane, *i.e.,* the plane which passes through the sulcus, the joint of 1″ and 9″, and the apex. This plate is variable but generally it has a convex left side subdivided into two edges for 2′ and 3′, a concave side which touches 1′, a major pole for 4′, and a minor one for the suture between 1′ and 2′. The most characteristic feature of this plate is a long and narrow reinforcement at the middle of the plate, sigmoid, with a dorsal hook to the right; it is variable sometimes double. Along it there are sometimes a few very small pores.

The most characteristic precingulars are 1″ and 9″. The first, trapezoidal in shape, is the smallest. The precingular 9″, pentagonal, has two edges at the left: the superior one for 1′ and the posterior, reinforced, forms a part of the right border of the sulcus. The precingulars 3″, 5″, and 7″ are more or less quadrangular.

The hypothecal formula is 7‴, 2‴ and 1p. The narrowest postcingular plates are 1‴ and 7‴. The latter is the smaller and is somewhat displaced posteriorly. The antapicals are very asymmetrical, the left one being much longer. The suture between 1‴ and 2‴ is irregular. Antapical 2‴ contacts the sulcus more than 1‴, which just barely touches it. The intercalary (p) is a large irregular plate, bordered by the antapicals, 3‴, 4‴ and 5‴.

All plates of the epi- and hypotheca are smooth. Some spots of different optical densities could be seen in a few specimens, especially in plate 1″, with oil immersion and phase contrast. There are sometimes pores located on the cingular border of this plate.

The cingulum is formed by eleven subequal retangular plates, plus another different plate at its right end. This $C_{12}$ is curved, irregular, extending somewhat into the sulcus, with a narrow left-posterior or sulcal end. For that reason this plate could be named "transitional." The cingular plates lack sculptures.

The sulcus is narrow, has six plates, and is only slightly excavated. The anterior sulcal plate has a very characteristic "boomerang" shape, with a posterior concavity and a longer and narrower right arm. In its sinus there are two very tiny platelets; the right one is the smaller. Behind the anterior plate and in contact with 1‴ there is a long plate, with a little sinus at the middle of its right border, where $C_{12}$ ends. In connection with the latter, there is another small plate. Finally, there is a posterior sulcal plate.

*Protoplasm.* The protoplasm is surrounded by a strong membrane and contains more than one hundred elongate-elliptical chromatophores which are dark

yellowish-brown. Food is stored as numerous granules of variable shape, which are generally small and located most abundantly in the peripheral layer.

The nucleus is large and compact, and is surrounded by a strong membrane. It is elongated in the equatorial plane, is somewhat curved, and has very dense thin threads of granular chromatin more or less perpendicular to the major axis of the nucleus. At the concavity, I sometimes observed large masses that were not distinctly granular.

The longitudinal flagellum extends beyond the antapex about two and a half cell lengths; it has a fast vibratory movement of short amplitude. The transverse flagellum, very slightly flattened, is long and completely encircles the girdle. The organism swims with a predominantly rotating motion.

*Dimensions* (in fixed and slightly distorted cells). Length 53–56 $\mu$; transdiameter 48–54 $\mu$. In an individual with a length of 55.5 $\mu$, the epitheca was 27.5 $\mu$ and the hypotheca was 24 $\mu$ in length.

*Variations.* I have observed some variation in form (cell length more or less short in comparison with the transdiameter) and also in the plate pattern. Sometimes 4″ appears divided into two plates; thus the postcingular series sometimes has eight instead of seven plates. Occasionally there are eight instead of nine precingulars, and in one individual, a very narrow 1′ was observed fused with the pore platelet.

The normal formula is: 4′, 9″, a pore platelet, 12c, 7‴, 2⁗, 1p and 6s.

*Discussion*

The only difficulty encountered in the tabulation of this organism was the rapidity with which it exuviated its plates. Most of the individuals were found in a quiet state, short ellipsoidal in form, and without theca. The actively swimming cells were of course difficult to measure and draw. Any attempt to stop them for a moment led to cell deformation and ecdysis. This is accomplished in a very peculiar way: all the plates separate from each other, but in general, they remain surrounding the cell at a short distance, forming a regular assemblage. The plates are very delicate.

The plate pattern of this species is fundamentally different from all of those previously known (Balech, 1956; Biecheler, 1952; Dangeard, 1927; Graham, 1942; Kofoid, 1907–33; Lindemann, 1928; Schiller, 1933, 1937). The differences are in both the epi- and hypotheca. Since very little is known regarding the cingulum and sulcus of most dinoflagellates, we cannot discuss the differences concerning these regions. Nevertheless, it should be pointed out that the structure of the sulcus of this species is different from that of all sulci already studied, and no other genus is known with such a high number of girdle plates.

Other genera without epithecal intercalaries and with four apical plates are *Diplopsalis, Dolichodinium, Goniodinium, Glenodinium, Cladopyxis*, and *Ceratium*. The two latter are very different in form, bearing strong horns or arms, and with many differences in plate pattern. *Diplopsalis* as defined by Lindemann (1928) is actually an assemblage of several genera. But even on these terms, *Diplopsalis* never has more than seven precingulars, five postcingulars and it lacks the posterior intercalary. *Glenodinium*, as defined by Schiller (1933–37), is another very heterogeneous assemblage with a very large variation of plate patterns. None of its

species has so many pre- and postcingular plates, and they also lack posterior intercalaries. *Dolichodinium* seems to have only six girdle plates and has six precingulars and six postcingulars instead of nine and seven. *Goniodinium* is perhaps the genus most closely related to *Fragilidium*, but it has only six precingulars and six postcingulars; instead of one posterior intercalary it has three intercalaries in the hypotheca. Until the discovery of *Fragilidium*, *Goniodinium* was the genus with the highest known number (nine) of cingular plates (this number, however, was not stated with certainty).

The high number of precingular, postcingular and cingular plates is sufficient to characterize this new genus. The only other genera with seven postcingulars are *Glenodiniopsis* and *Heterodinium*. *Pyrophacus* is the only genus with a higher number of these plates.

*Fragilidium heterolobum* was isolated from plankton at La Jolla (San Diego, California) on March 20, 1957.

## Summary

1. Two new genera and species of dinoflagellates are described. Both were originally isolated from plankton samples collected at La Jolla (San Diego, California).

2. *Scrippsiella sweeneyi* is a small species with the general tabulation of an *Orthoperidinium*, but it differs in having six cingular plates. The structure of the sulcus is also different. A great deal of variation in plate pattern was exhibited by this organism.

3. *Fragilidium heterolobum* is a medium-sized species having a tabulation that is quite different from all previously described dinoflagellates. It has a very high number of cingular plates (twelve). The generic name refers to the characteristic frequency and suddenness with which it sheds its plates.

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